CIRCULAR No. 35 JUNE, 1928

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

THE COMMERCIAL PRODUCTION OF SAUERKRAUT

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INTRODUCTION

Sauerkraut is shredded cabbage which has undergone a lactic fermentation in the brine made from its own juice by the addition of salt.

Just when or where sauerkraut was first made is not known. A popular conception, based largely on the name and the fact that it is popular with German people, is that it originated in Germany. This is probably not true. It is known to have been made at an early date in Alsace, now a part of France, and also in Holland, where the manufacture of sauerkraut is still an important industry. Henneberg (*9*)[1] who investigated this subject, ascribes its origin to the Tartars. They introduced it among the Slavic peoples of eastern Europe, who in turn introduced it into Germany. If Henneberg's statement, which is based mainly on tradition, is correct, sauerkraut is of Asiatic rather than European origin. Whatever the facts of its origin may be, at an early date its use became general over all northern and central Europe. The Germans were, in all probability, the first to develop efficient methods for its production and after the development of the science of bacteriology were the first to study the processes involved in its fermentation.

[1] Italic numbers in parentheses refer to "Literature cited," p. 29.

Sauerkraut was probably introduced into the United States by German immigrants, who, coming in large numbers, spread its popularity as a food. The demand for it, especially among people in the cities, who lacked facilities for making it themselves, soon led to its commercial production.

Sauerkraut was first made commercially in this country in St. Louis, but, like many other industries, it soon sought the localities where the raw material is produced at its best and most abundantly. These localities were found in the North Central States, chiefly in those sections which border on the Great Lakes. Most of the factories devoted wholly or in part to the manufacture of sauerkraut are now within this territory.

ECONOMIC IMPORTANCE

Since its development on a commercial basis in the United States, about 1890, the manufacture of sauerkraut has become an important industry. There are now in this country many factories devoted wholly or in part to the making of sauerkraut in which a large amount of capital is invested and in which several thousand people are employed.

It is estimated that about one-seventh of the total commercial production of cabbage in this country is made into sauerkraut. The quantity of cabbage used for this purpose varies from year to year, depending largely on the size of the crop. When the crop is large and consequently prices are low more sauerkraut is made than when the supply is short and the prices are high. Making sauerkraut affords an excellent means of utilizing all excess cabbage.

Table 1 shows the quantity of cabbage made into sauerkraut from 1917 to 1927, inclusive, according to reports made to the Bureau of Agricultural Economics, United States Department of Agriculture.

TABLE 1.—*Cabbage made into sauerkraut, 1917–1927*

Year	Cabbage	Year	Cabbage	Year	Cabbage
	Tons		*Tons*		*Tons*
1917	124,849	1921	64,900	1925	89,800
1918	116,500	1922	160,800	1926	101,400
1919	47,900	1923	166,600	1927	163,100
1920	67,100	1924	121,200		

As these figures are based on reports from large manufacturers and do not take into account the cabbage used by small manufacturers and dealers who obtain their supply largely on the open market, they probably do not represent more than two-thirds of the actual quantity of cabbage made into sauerkraut. On that basis, during 1923, for example, approximately 250,000 tons of cabbage was used in the commercial production of sauerkraut. At $9.50 per ton, which was the average price of cabbage for that year, nearly $2,500,000 worth of cabbage was made into sauerkraut.

Reports made by the National Kraut Packers' Association, together with a conservative estimate of that made by other manufacturers, indicate that the average annual production of sauerkraut in the United States is not less than 400,000 45-gallon barrels. At the

average price of $9 a ton, the value of this output would be more than $3,500,000.

DIETETIC VALUE

The chemical composition of cabbage varies somewhat from year to year; probably it varies in cabbage grown in different localities during the same year. Also the several varieties may differ. Its edible portion contains about 90 per cent of water and 10 per cent of solids. Table 2 gives the chemical composition of cabbage as determined by Conrad (*5*). The analyses of cabbage so far made in the United States do not show any outstanding differences from the results obtained by Conrad except in the sugar content. Peterson, Fred, and Viljoen (*17*) reported sugar determinations on 19 samples of cabbage comprising five varieties from various parts of the country. The average sugar content of these samples was 3.4 per cent, the maximum being 4.2 per cent and the minimum 2.9 per cent.

TABLE 2.—*Chemical composition of cabbage*

Water	Crude protein	Fat	Sugars as dextrose	Crude fiber	Ash
Per cent 91.1	*Per cent* 1.5	*Per cent* 0.1	*Per cent* 4.2	*Per cent* 1.1	*Per cent* 0.8

Sauerkraut has about the same chemical composition as cabbage. The principal differences are the added salt and the acids, which, as a result of fermentation, largely replace the sugar of the cabbage. These changes render it decidedly more palatable to many people and do not detract materially from its food value.

Although it has no great nutritive value as measured by calories, sauerkraut is a wholesome and appetizing food. Primarily it is valuable because it affords an additional bulky vegetable product for winter, when the diet of most people consists too largely of concentrated forms of food. Chemical analyses have shown that cabbage contains calcium, phosphorus, and iron, as well as other mineral constituents required for human nutrition. The acids in sauerkraut are by no means unimportant as food constituents. Experiments have demonstrated that they are consumed in the body with the production of energy.

The vitamin content of sauerkraut has not yet been definitely determined. Cabbage contains the three vitamins A, B, and C. Except when green, cabbage is not, however, a good source of vitamin A. It is a good source of vitamin B and one of the best sources of vitamin C (*19, p. 599*). Investigations by Ellis, Steenbock, and Hart (*6*) have shown that vitamin C is largely destroyed by fermentation. From what is known concerning the stability of vitamins A and B, however, it is safe to say that if they are in the raw cabbage they are also in the fermented product.

BACTERIOLOGY OF SAUERKRAUT PRODUCTION

The Germans were the first to study the bacteriology of sauerkraut production. Although previous references had been made in Ger-

man scientific literature to the fact that the production of sauerkraut was the result of a lactic fermentation caused by the activity of certain organisms, no systematic study of this problem was reported before that by Conrad (*5*). He reported that he had isolated an organism which, in symbiotic relation with certain yeasts that he had isolated, he believed to be the causative agent in this fermentation. Conrad's description indicates that the bacterium he isolated was probably a member of the colon group. He himself questioned whether it could be classed as a species distinct from that group.

Wehmer (*22*) in 1903 published a preliminary paper on the fermentation of cabbage. This was followed in 1905 by a lengthy report (*23*) covering his investigations on this subject from 1892 to 1903. In this report he described an acid-producing organism which he believed to be the essential factor in the fermentation of cabbage and which he called *Bacterium brassicae*. Wehmer, too, believed that yeasts acting symbiotically were an important factor in the fermentation. He believed that the bacteria produced the acid and that the yeasts were responsible for the flavor and gas production. Wehmer showed that a necessary condition in this fermentation was the exclusion of air and that this was dependent upon a rapid brine formation, which could be produced by the addition of sodium chloride. He also called attention to the fact that *Oidium lactis* and *Mycoderma* may rapidly destroy the acid and later the sauerkraut beneath. To Wehmer, therefore, is undoubtedly due the credit of discovering the organism essential in sauerkraut fermentation. His results were also the first to afford a scientific basis for procedure in sauerkraut production.

Butjagin (*4*) reported investigations as a result of which he agreed with Wehmer that the organism described by the latter is an important organism in the fermentation of cabbage, but stated that other organisms may be able to ferment it more or less completely.

Henneberg (*8*) and Perekalin (*15*) described organisms isolated from sauerkraut, but from their description of these organisms they can not be classified definitely with that described by Wehmer or connected distinctly with the fermentation of cabbage.

In the United States the first notable investigation in the bacteriology of sauerkraut was that of Round (*18*). While working in the Bureau of Chemistry he made an extensive investigation of the factors involved in the fermentation of cabbage. He confirmed the claim of Wehmer that the organism responsible for the fermentation of cabbage is identical with or closely related to *Bacterium brassicæ*. Also, he confirmed Wehmer's findings that the essential function of salt is to withdraw the juices from the cells and produce anaerobic conditions, and that, aside from this, the salt has no important action except to flavor the product. Round, however, did not agree with Wehmer's contention that yeasts play an important part in this fermentation. He believed that the gas formation in sauerkraut fermentation is not caused by the action of the organisms but is the result of the large quantities of carbon dioxide given off by the plant cells, and that the escape of this gas produced the so-called foaming or working in sauerkraut tanks.

Round correctly held that this fermentation results from the action of a lactobacillus or possibly a group of lactobacilli identical with that described by Wehmer and that yeasts have no essential part in the fermentation of cabbage or any of the other brined products. It has been shown that although yeasts are present at the beginning of a fermentation they soon cease to be active because of unfavorable conditions; the acid and salt content as well as the anaerobic condition in fermenting cabbage are unfavorable for their growth and activity. As a matter of fact, if yeasts are present at all in brine taken from the depths of a normally fermented tank of sauerkraut, they are so few that they may be regarded as negligible.

Most of the early investigators of this subject appear to have assumed that organisms found at the beginning of a fermentation or close to the surface of a vat are essential factors. As they failed to recognize the anaerobic nature of the fermentation, much of their investigational work was based on the fermentation of small samples or on samples taken from the surface of fermenting vats. Naturally this led to many erroneous conclusions.

Fig. 1.—Lactic bacteria from fermenting sauerkraut juice. ×1,200

Various strains of lactobacilli are responsible for the fermentation of vegetable products, and most of them can be studied under very favorable conditions in fermenting cabbage. These organisms are always present in large numbers on vegetables which grow close to the ground, and they are usually found in the soil, perhaps owing to the presence of decaying vegetable matter.

The typical shape of organisms of this group is that of a slim rod from 2 to 6 microns in length. (Fig. 1.) Some are shorter and thicker, however, and many approach a coccoid formation. They are Gram-positive, nonmotile, and nonspore bearing. Although they are not strict anaerobes, these organisms are so strongly inhibited by free oxygen that they can grow satisfactorily only under at least partly anaerobic conditions. The optimum temperature for their growth is approximately 30° C. (86° F.), and their activity decreases decidedly by a departure from this optimum in either direction. Experiments have shown, for example, that their fermentative activity decreases in about the same ratio as the temperature of the substratum in which they operate falls below this optimum. The thermal death point of the sauerkraut group is approximately 55° C. (131° F.)

The lactobacilli of vegetable fermentations do not grow well in most of the usual culture media; for this reason they are often overlooked in ordinary laboratory procedure. Media containing meat juices are especially unfavorable for their growth, and they grow slowly or not at all in milk. They have a particular affinity for the vegetable juices, particularly those of cucumbers and cabbage. In these they grow luxuriantly and characteristically and form comparatively large quantities of acid.

Acid formation depends upon the kind and quantity of sugar present. Under favorable conditions of temperature and anaerobiosis, from 1½ to 2 per cent of total acid, expressed as lactic, is formed in cabbage juice. The acid is mainly lactic, but some acetic acid and a small quantity of ethyl alcohol are formed. This group of organisms is tolerant of salt; in fact, growth seems to be accelerated by the addition of small quantities of salt.

Gas formation by this group is not shown by the common laboratory methods. That they do form gas, however, in a favorable medium and under anaerobic conditions has been definitely demonstrated, and the gas formation in tanks of sauerkraut is doubtless caused, in part at least, by the activity of these organisms.

The organisms which are essential in the fermentation of cabbage belong clearly to the Lactobacillaceæ. They exist under somewhat different forms, and various strains produce slightly different biochemical results. These variations have led to the opinion that they are not one species but a group, and they are often referred to as a group. In all essential particulars, however, their cultural characteristics are sufficiently concordant to classify them as a single species. Under the present rules for bacteriological nomenclature, this species should be called *Lactobacillus brassicus.*

THE USE OF PURE CULTURES AS STARTERS

The advantages gained by the use of pure cultures of desirable organisms as starters in the fermentation or souring of food products have long been recognized. The addition of starters to cream or milk in the making of butter or certain forms of cheese and to fruit juices in the production of vinegar are familiar examples. It was but natural, therefore, that this method should have been considered in connection with the making of sauerkraut. The first experiments looking to this end were made in Germany. Gruber (*7*) reported a series of experiments in which he used small tubs holding from 5 to 10 liters of cabbage. As a result of inoculations with a culture of a lactic organism which he called *Pseudamonas brassica acidæ*, he claims to have hastened the beginning of fermentation and likewise to have produced better-flavored sauerkraut. He admitted, however, that the method has certain disadvantages.

In this country the use of pure cultures was suggested by several investigators, and experiments under commercial conditions have been reported by the writer (*11, 12*). The first experiment cited was conducted with four tanks of cabbage which had not been preheated. To the cabbage in two of the tanks was added a culture of an organism which had been isolated from sauerkraut and which had proved to be a good acid-producing strain. The highest acidity

reached in these tanks was 1.71 and 1.67 per cent, calculated as lactic; the time required for each was 16 days. In the tanks to which no culture was added the highest acidity was 1.67 and 1.58 per cent, reached in 17 and 16 days, respectively.

In the other experiment two tanks of preheated cabbage were used. A culture from the same strain as that used in the first experiment was added to one. In this tank the highest acidity determined, 1.89 per cent, calculated as lactic, was reached in eight days. The tank to which no culture was added reached its highest acidity, 1.8 per cent, in the same length of time. Although in both these experiments slightly better results were obtained with the aid of the added culture, the differences were not of great practical importance.

These experiments were carried out solely with a view to shortening the time of fermentation and increasing acid production. The possibility of improving flavor by means of properly selected cultures has been suggested, and some experiments by Brunkow, Peterson, and Fred (*3*) have indicated that flavor can be improved in this way. It must be kept in mind, however, that organisms of the lactic group are always on cabbage in large numbers. It is manifestly impossible, therefore, to obtain the results of a pure strain.

The difficulties in the way of using pure cultures under commercial conditions are so many and control is so difficult that their use does not seem to be warranted unless it can be shown that they are of material benefit. So far such benefit has not been demonstrated.

INFLUENCE OF HEAT ON SAUERKRAUT PRODUCTION

The fact that this group of lactic bacteria show their greatest biochemical activity at a temperature of 86° F. and that this activity fails progressively as the temperature of the substratum falls below the optimum has been mentioned. This is in harmony with the common experience of sauerkraut producers that sauerkraut ferments much more rapidly in warm weather than in cold weather. Unfortunately, in those sections of the country in which this industry has obtained its firmest foothold the weather is usually cold during the sauerkraut-producing season. When it comes to the factory cabbage has about the temperature of the atmosphere, which means that in the colder months of the sauerkraut season the cabbage is extremely cold, often below 60° F. Manufacturers have sought to overcome this handicap by heating tank rooms and, in some instances, by placing steam coils around the tanks. For the most part, however, these expedients have failed. Heat penetrates the walls of a tank slowly, and most of it reaches only the outer layers of cabbage. To obtain the proper temperature in the center of a large tank without overheating the outer zone is difficult; in fact, it is physically impossible to maintain a satisfactory degree of heat in a tank of cabbage by heat applied outside the tank.

The possibility of heating cabbage by its own metabolism during storage has been suggested. This method has proved inadequate for the reason that the cabbage is not heated evenly. The cabbage which is covered at the bottom of a bin is heated rapidly and soon undergoes decomposition, whereas that at the top and sides, where direct radiation takes place, is heated slowly, if at all.

The only plan which seems to solve this problem is that of heating the shredded cabbage before it goes into the tank. In an experiment carried out under commercial conditions by the writer (*12*), it was shown that this can be done successfully by the application of steam. In this experiment the sloping belt which carried the shredded cabbage from the cutting machine to the cart was inclosed. Steam was conveyed into this inclosure by coils of pipe which were arranged over the lower end of the belt. The steam, which was ejected through small holes in the lower sides of the pipes, passed through the inclosure and escaped at the upper end, gradually warming the cabbage as it was conveyed from the cutting machine on the first floor to the cart on the second floor. The temperature of the cabbage was 59° F. as it entered the conveyor; after the steam was turned on the temperature rose and was 86° F. as the cabbage entered the cart. Approximately 86° F. was easily maintained. After the cabbage was spread in the tank it still had a temperature of 80° F. That this was sufficient to produce a fairly rapid and at the same time satisfactory fermentation was shown by the results. In two tanks of cabbage which were heated in this way the acidity, calculated as lactic, reached 1.8 and 1.89 per cent, respectively, in eight days. By the usual factory tests for determining the completion of fermentation (p. 17) this cabbage was pronounced fully fermented. In a control tank, in which no heat was used, the acidity in the same length of time reached 1.4 per cent, and the cabbage was not properly fermented.

The data obtained from this experiment demonstrated clearly that if cabbage goes into a tank at the optimum temperature for the essential organisms, or near it, their fermenting activity starts promptly, as shown by a rapid increase in acidity, and, as a result of this prompt activity, the fermentation is completed rapidly and satisfactorily. If, on the other hand, the cabbage goes into a tank cold the activity of these organisms is much retarded and the fermentation is prolonged. The final result is not so likely to be satisfactory. The data showed, moreover, that when cabbage is preheated the initial temperature is not only maintained but is somewhat increased as a result of the chemical action, regardless of the temperature outside the tank. For this reason the heating of tank rooms, although desirable, is not essential.

The preheating of cabbage must be carefully worked out and controlled to avoid overheating or scalding. In no case should the cabbage be heated to a temperature above the optimum for the lactic bacteria (86° F.). In fact, it has been found that a temperature slightly below the optimum will usually produce the desired result; a temperature above the optimum may cause an abnormal bacterial activity, probably by stimulating the growth of undesirable organisms. In some instances this has resulted in the softening of the cabbage. In preheating cabbage it is never safe to determine its temperature with the hand. The temperature of the cabbage as it enters the cart or preferably the tank should be determined by a reliable thermometer.

FACTORS WHICH INFLUENCE THE QUALITY OF SAUERKRAUT

CABBAGE [2]

Almost any variety of cabbage may be used for making sauerkraut, but some varieties are more suitable for this purpose. Just as in the pickle industry the slow-growing and solid-fruiting varieties of cucumbers are preferred, in the making of sauerkraut the slow-growing and solid-headed varieties of cabbage are preferable . (Fig. 2.) Such varieties are All Seasons, Glory of Enkhuizen, All Head Early, Flat Dutch, and Copenhagen Market. Perhaps no one of

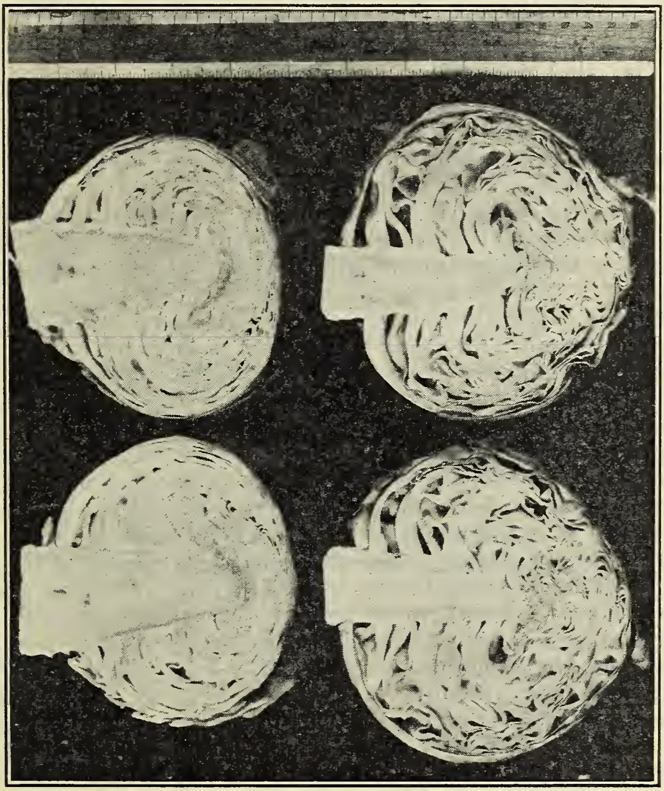

FIG. 2.—Cross sections of a closely filled and a loosely filled head of cabbage

them, however, can be grown successfully in all sections of this country. Adaptability to conditions of soil and climate, therefore, should always be considered in the selection of varieties.

Whatever variety is used, the cabbage should be fully matured before it is cut. Some growers harvest this crop too soon, presumably with a view to getting it out of the way of other work, and as a result it is not matured properly. Sauerkraut made from green cabbage

[2] Information on the cultivation and diseases of cabbage may be obtained from the Bureau of Plant Industry, United States Department of Agriculture.

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will show defects in color and texture; usually it will be spotted and coarse. Good raw material is a fundamental requirement in the production of high-grade sauerkraut. It is useless to expect to make a first-class product with any but sound and well-matured cabbage.

ACIDITY

The quality of sauerkraut depends also upon a number of other factors. Of these the acidity is most important, as it is the primary characteristic and is essential to the preservation. Without acidity sauerkraut is flat and insipid. The acid in sauerkraut is formed from the sugar, which is one of the constituents of cabbage. Sugar exists in cabbage chiefly in the form of dextrose and invert sugar, and to a much smaller extent as sucrose and pentose. The sugar content of cabbage has been variously estimated at from 3 to 4½ per cent. As the data available were obtained by isolated examinations of comparatively few samples, many analyses are needed to show the chemical constituents of this vegetable under various conditions of growth and environment.

All the sugars contained in cabbage are fermentable by the group of lactic bacteria which are always present on cabbage; hence all contribute to the formation of acid. When added to the shredded cabbage salt withdraws by osmotic force the juices of the vegetable, including the sugars held in solution. The lactic bacteria at once attack these sugars and from them form lactic acid, together with much smaller quantities of acetic acid and ethyl alcohol.

If it is assumed that the sugar content of cabbage is 4 per cent, a quantity of acid should be produced which is about equal to one-half the quantity of sugar, namely, 2 per cent. This proportion of acid, however, is rarely produced in the fermentation of cabbage. In some instances this may be owing in part to a deficiency in sugar, but generally it is the result of incomplete utilization of the sugar. Sauerkraut nearly always contains residual sugar unless it has undergone a secondary fermentation by the action of either yeasts or bacteria. Under normal conditions an acidity equivalent to 1.8 per cent may be considered satisfactory, but often it is less. A normal fermentation should not show an acidity of less than 1.5 per cent; a lower acidity indicates either a deficiency of sugar in the cabbage or a failure in the fermentation. A lower minimum is permissible, however, after repacking either in bulk or in cans, because of the dilution which results from rebrining.

So important is the degree of acidity to the quality of sauerkraut that it should always be kept under observation. For this purpose every factory should be equipped with the necessary outfit for determining acidity and frequent tests should be made to determine just when the maximum degree has been reached. Such testing furnishes a certain means of knowing when the fermentation is complete and gives correct information on the final degree of acidity attained. In this, as in all lactic fermentations, the narrow range of acid formation necessitates quantitative methods for its determination. It can be determined accurately enough by titrating the brine against an alkaline solution of known strength (p. 24).

SALT

Salt is essential in the production of sauerkraut; it withdraws the juice and gives an agreeable flavor. Shredded cabbage covered with water will ferment, but it will not make sauerkraut. It is not necessary that fine-grained salt be used. In view of the fact that a very fine salt clumps more readily on handling, it is perhaps better that it should be only medium fine. Salt used for this purpose should flow freely; that is, it should be dry and not caked or lumpy. This is essential in order that it may be distributed evenly. It should be as free as possible from chemical impurities, especially alkaline impurities and those which would favor the absorption of moisture. Any salt which contains no more than the quantities of impurities given in the following list is suitable for the production of sauerkraut:

Carbonate or bicarbonate of sodium, calcium, or magnesium	per cent	1.0
Chlorides of calcium or magnesium	do	0.5
Calcium sulphate	do	1.4
Matters insoluble in water	do	0.1

The quantity of salt used should range from 2 to 3 per cent of the weight of the shredded cabbage. Less than 2 per cent may not produce the necessary osmosis; moreover, it may give a more or less insipid flavor. On the other hand, the addition of more than 3 per cent of salt would retard the activity of the essential organisms and make the flavor too salty. A mean between these extremes, therefore, is desirable. Many manufacturers, possibly most of them, add salt in the proportion of approximately 2½ per cent of the weight of the shredded cabbage. Their results seem to justify this plan.

CUT

The acidity and the salt content are undoubtedly the controlling factors in the flavor of sauerkraut. Other factors, however, contribute to the quality of the sauerkraut. Among these the cut is important. Some sauerkraut manufacturers believe that it should be cut as thin as possible, and others favor a thicker cut; here, again, a mean between extreme views should be adopted. Thinness in cut is undoubtedly desirable in sauerkraut, unless carried to an extreme, which would make the product soft and mushy. A thick cut gives it an unattractive appearance. A cut about the thickness of a dime (approximately one thirty-second of an inch), which is a standard fixed by a number of manufacturers, appears to be desirable.

CRISPNESS

Sauerkraut should be crisp; that is, the shreds should be intact and fairly firm and yet be easy to masticate. It must never be soft and mushy on the one hand or hard and tough on the other. Crispness improves the flavor. It is especially difficult in canned sauerkraut to retain the crispness, as it is easily destroyed by overheating.

COLOR

Sauerkraut should have as little color as possible. The absence of color makes the product more attractive and also indicates proper handling. As certain varieties of cabbage are believed to produce

sauerkraut having more color than others, color in sauerkraut which is owing to the age or variety of the cabbage is not subject to control by the manufacturer and is not necessarily indicative of inferiority, but color which is caused by improper handling is the fault of the manufacturer. Two factors essential in avoiding color in sauerkraut are fairly rapid fermentation and a reasonably prompt distribution after fermentation is complete. Long holding in tanks almost always causes coloring.

THE SAUERKRAUT FACTORY

LOCATION

The first consideration in the location of a sauerkraut factory is that it should be in a good cabbage-producing region. The manufacturer of sauerkraut must depend for his supply of cabbage pri-

FIG. 3.—Cabbage being brought to the sauerkraut factory

marily on that brought by short hauls direct from the grower. (Fig. 3.) It is sometimes necessary to supplement the local supply with that shipped from a distance, but cabbage is too bulky, and the uncertainties of obtaining a constant supply by rail shipments are too great to make this a desirable method of supply. Another factor to be considered is the possibility of securing help during the sauerkraut-producing season. In a rural community this is likely to be a serious problem and always should be given careful attention.

The site for the building of the sauerkraut plant should be determined by accessibility and convenience for the delivery of cabbage and likewise by the facilities for shipping the finished product.

BUILDING

It would be impossible to give specific directions for building a sauerkraut factory, for the reason that the size and plans for such a plant must depend largely on the capacity desired, local condi-

tions, and the individual preferences of the manufacturer. Therefore, only general directions are given.

The building (fig. 4) should be constructed preferably of fireproof material. It should have at least two floors and a basement, with ample provision for light, ventilation, and drainage. Steam heating is desirable. Space should be provided for an office, for bins to receive the cabbage, for trimming, coring, and cutting the cabbage, for a tank room, salt room, boiler, engine, and for storage of barrels and fuel. If the sauerkraut is to be canned additional space must be provided for canning machinery and for packing, labeling, and storing the cans.

The bins into which the cabbage is delivered by the growers are an important part of the sauerkraut factory. They may be on one side of the building (fig. 5) or in an additional wing. If an additional wing is provided for this purpose two parallel rows of bins should be constructed with space between for trimming, coring, and

FIG. 4.—Sauerkraut factory

cutting the cabbage. This space should be ample for the comfort and convenience of the employees and should be well lighted and ventilated.

A system of conveyers is provided to carry the cabbage from one operation to the next.

PROCEDURE

CUTTING THE CABBAGE

The proper cutting of the cabbage into shreds is important. Better results can be obtained after the cabbage has wilted in the bins for from 24 to 48 hours. Wilted cabbage is less brittle, and as a result longer shreds can be cut.

The method of procedure differs somewhat in various plants. Usually the men who operate machines for cutting the cores take the cabbage from the bins and impinge it, stock end first, on the coring machine. This machine consists of a rapidly revolving arm which has a small blade close to its free, pointed end. It quickly cuts

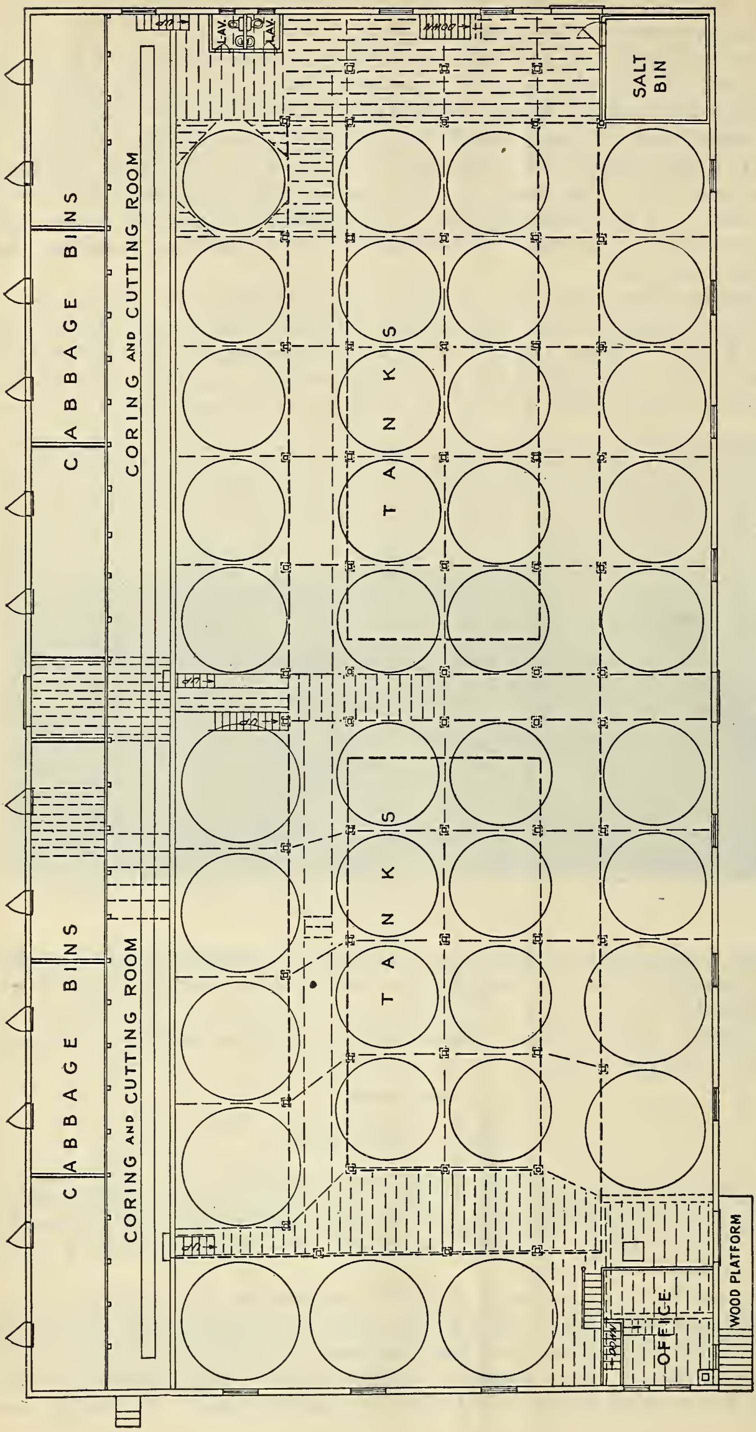


FIG. 5.—Diagram of first floor of sauerkraut factory

the core into small pieces. The cabbage is then carried on a constantly moving belt to helpers who remove the outer leaves and trim off all ragged and dirty parts. (Fig. 6.) The waste material is carried away by one belt; the solid heads are thrown on another belt, which conveys them to the cutting machines.

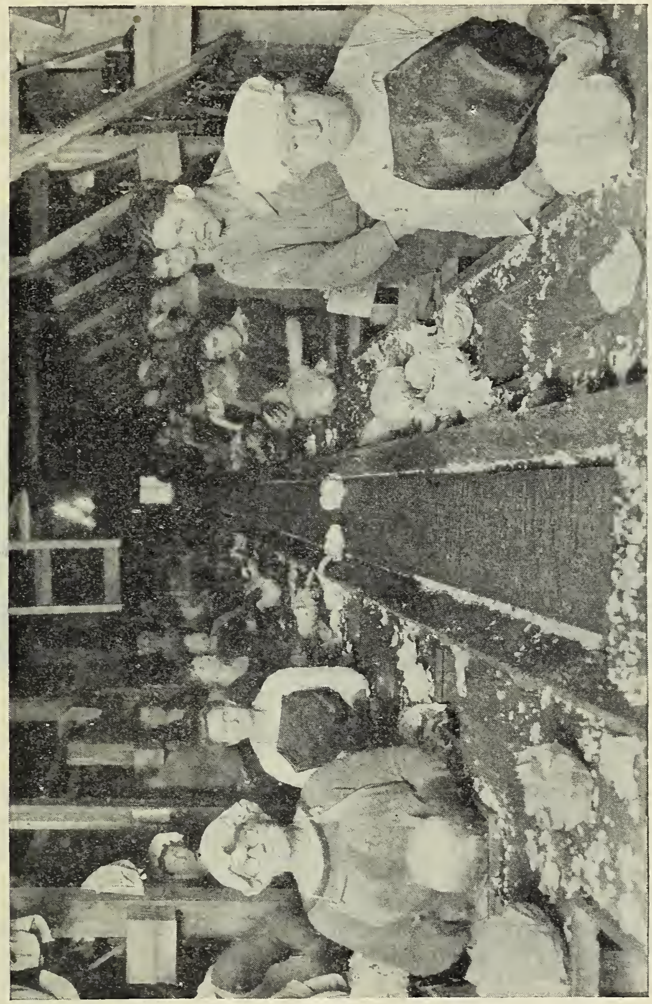


Fig. 6.—Coring and trimming room

The cutting machines (fig. 7) consist essentially of a cylindrical hopper, the bottom of which is formed by a number of sharp curved blades, and which is capable of rapid revolution. These blades, which partly overlap, can be set to cut pieces of any thickness desired. All cutting machines are constructed along similar lines but differ in capacity. To operate a large machine with maximum efficiency two or three men are required. In a large factory where three cutting machines are operated, each by two men, from 30 to 40 people are required to supply them with cabbage.

SALTING THE CABBAGE

After it is cut the cabbage falls on a conveying belt which carries it either directly to the tank or to the floor above, where it drops into a cart. It may be salted either as it enters the cart or after it enters the tank. (Fig. 8.) When the cabbage is salted before it enters the tank one man in the tank can spread it properly, but when it is salted in the tank two men are required, one for spreading and one for salting. Salting the cabbage before it enters the tank, which is the procedure perhaps most commonly followed, affords a good means for a thorough distribution. Distributing the salt in the tank, however, offers a better opportunity for regulating the proportion of salt to be used.

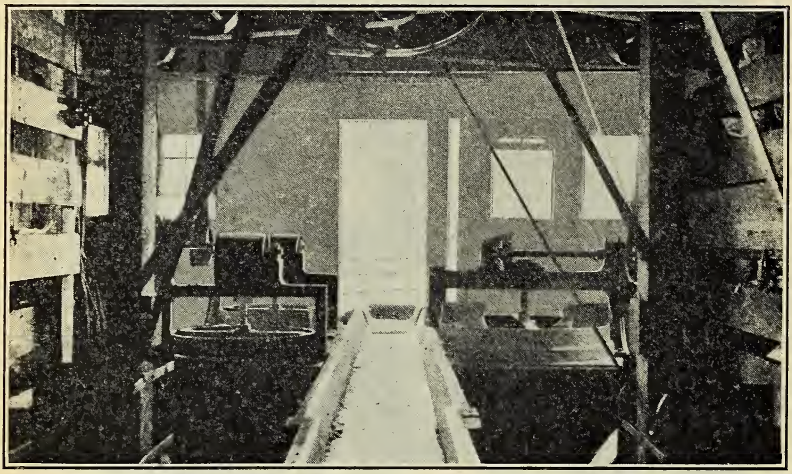


Fig. 7.—Cutting machines

FILLING THE TANKS

Unlike those used by European manufacturers, tanks for fermenting cabbage in the United States are usually large, ranging from 8 to 10 feet in depth and from 12 to 16 feet in diameter and having a capacity of from 30 to 40 tons. In many factories, however, which have a limited output or which supply only a local demand, the tanks are much smaller. In size these conform closely to the tanks used in Europe; the dimensions are about one-half those of the large tanks. A few small tanks should be provided in every factory for use in case only a small quantity of cabbage is to be cut.

Most tanks in this country are now made of wood. Concrete tanks, once popular, are no longer used by preference. Cypress and redwood are believed to be the best woods for this purpose, but some are made of spruce, fir, and white pine. Tanks are sometimes coated on the inside with paraffin or other protective mixtures, but if they are made of durable wood this is believed to be unnecessary.

The tanks should be set on a concrete foundation on the basement floor at an elevation sufficient to bring the top of the tanks about 2½

or 3 feet above the level of the first floor. An opening at the bottom which will permit perfect drainage must be provided. When tanks are filled from the second floor hatchways are provided directly above the tanks.

Usually the tanks are filled even with the top or slightly above it. They are then covered with boards made up into three or four sections, which are weighted down with large stones or concrete blocks. (Fig. 9.) Concrete blocks fitted with iron handles are very convenient for this purpose. The weight on a tank should be from 3,000 to 5,000 pounds, according to the size of the tank. Some manufacturers prefer the method of keying down the fermenting cabbage which is followed in the pickle industry. For this purpose 4 by 4 inch joists are placed across the cover and are braced down by blocks firmly supported at the top of the tank.

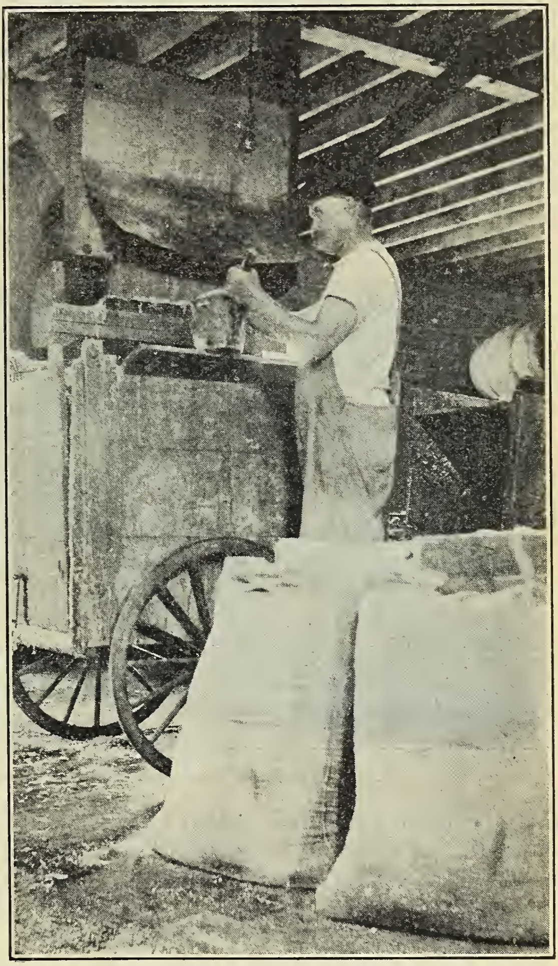


Fig. 8.—Salting the cabbage

FERMENTATION

The time required for the fermentation of shredded cabbage depends almost entirely on its temperature when it enters the tank. If it has a temperature favorable for the growth of the essential organisms, or near it, fermentation will usually be completed within 10 days (page 8). On the other hand, if the cabbage goes into the tank cold the time required may be twice or even three times as long. The objective signs of a completed fermentation, which have been largely depended upon in the past, are the cessation of bubbling and frothing, the settling of the cabbage in the tank, and the taste of the sauerkraut. None of these signs is, however, entirely dependable.

The only reliable indication of a completed fermentation is the acidity. As long as the acidity increases fermentation is continuing. When acidity no longer increases fermentation is complete, hence the importance of having a reliable means of knowing when the acidity has reached its maximum.

When sauerkraut has reached the point of maximum acidity it may be said to have reached its best quality. It will not improve by remaining longer in the tank and it may deteriorate. The deterioration may be slight as long as the weather is cold, but with the coming of warm weather secondary changes occur which are always unfavorable to the flavor and color of the sauerkraut. Holding sauerkraut in tanks from one season to the next should always be avoided, if possible. During hot weather expansion of both the solid and the liquid contents of the tank causes the brine to rise to the top of the tank and in some instances even to overflow. It becomes contaminated with spoilage organisms, and when the temperature falls

FIG. 9.—Tanks of fermenting cabbage

this germ-laden mixture, which may approach putridity, settles back into the tank, spreading its contaminating influences. A clean, wholesome product can not come from such an environment.

EMPTYING THE TANKS

As soon as sauerkraut is properly fermented the tanks may be emptied. First, however, the brine which has collected at the bottom of the tanks should be drained off by opening the bottom vent. Tanks are emptied most satisfactorily by means of portable conveyers, which convey the sauerkraut to the place desired. If it is to be packed in bulk it should not be removed from the tanks until time for shipment, as sauerkraut deteriorates much more rapidly in barrels than in the tanks, unless the barrels are stored at a low temperature. If the sauerkraut is to be packed in cans it is conveyed directly from the fermenting tank to the warming tank, where it is warmed in preparation for canning.

CANNING SAUERKRAUT

In many ways canning offers the best means for preserving and distributing sauerkraut. When it is sold in bulk the manufacturer can not control the condition in which it will reach the consumer. Barrels plugged tight may leak, or even burst, in shipment. Unplugged barrels subject the contents to infection and loss during handling. Generally sauerkraut reaches the dealer in a fairly satisfactory condition. Its treatment after it reaches the dealer, however, is often so lacking in measures which would insure its preservation that by the time it gets into the hands of the consumer it is dark and undergoing a yeasty fermentation. When a manufacturer produces sauerkraut of good quality and packs it properly in cans, he can rest assured that it will reach the consumer in practically the same condition in which it left his factory. Every sauerkraut manufacturer, therefore, might well become a canner.

Sauerkraut lends itself readily to the process of canning. It is comparatively easy to pack in cans, and after packing it is preserved without great difficulty. As compared with most vegetables, sauerkraut is a decidedly acid product. Investigations by Bigelow and Cathcart (*2*) have shown that its acidity as determined by its hydrogen-ion concentration is comparable with that of such fruits as raspberries, cherries, and blueberries, all of which have a PH value of less than 4. No other vegetable ordinarily canned, with the exception of rhubarb, contains as much acid as sauerkraut. Many groups of organisms, including those which are usually instrumental in the spoilage of canned foods, will not grow in sauerkraut because of its acidity.

In addition to its high acidity sauerkraut has a salt content of from 2 to 3 per cent, which is unfavorable for the growth of most spoilage organisms. When introduced into sauerkraut such organisms as *Clostridium sporogenes*, *Bacillus vulgatus*, and *Bacterium coli* not only do not multiply but after a short period in this environment usually are not capable of reproduction when transferred to a more favorable medium. Investigations by Koser (*10*) and Bachmann (*1*) have shown that *Clostridium botulinum* and the paratyphoid-enteritidis group of organisms, which are largely instrumental in causing food poisoning, do not grow or produce toxins when introduced into fermenting cabbage.

Repeated tests have shown that, as a rule, when sauerkraut comes out of the tank it contains but two groups of organisms which need to be reckoned with, namely, lactic bacteria and yeasts. The former are numerous and active, whereas the latter are few and inactive, but still are capable of rapid multiplication when placed under favorable conditions. Fortunately, both these groups are destroyed by a comparatively low temperature.

PRELIMINARY HEATING

Before it is canned sauerkraut is warmed in sauerkraut juice, which should be heated to about 40° C. (104° F.). A shallow tank fitted with steam coils is provided for this purpose close to the canning table. At the start it should be filled with sauerkraut juice in order that the acidity of the first sauerkraut put into it may not be

reduced. This preliminary heating is necessary for several reasons. It takes the place of the precooking which is used in canning various fruits and vegetables and in a similar manner renders the sauerkraut more easy to pack in the can. Its chief value, however, is that the contents of the can are much more quickly and evenly heated in the exhaust if previously warmed in this way. The added comfort to those who pack it in the cans is another point in favor of this preliminary heating, as much sauerkraut is canned in winter when the material is near a freezing temperature and the cans are usually filled by hand.

This preheating must be properly regulated. It is important that every batch of sauerkraut which passes through the warming tank should be subjected as far as possible to the same movements for the same length of time. The acidity and salt content of the brine in the warming tank should conform with that of normal sauerkraut

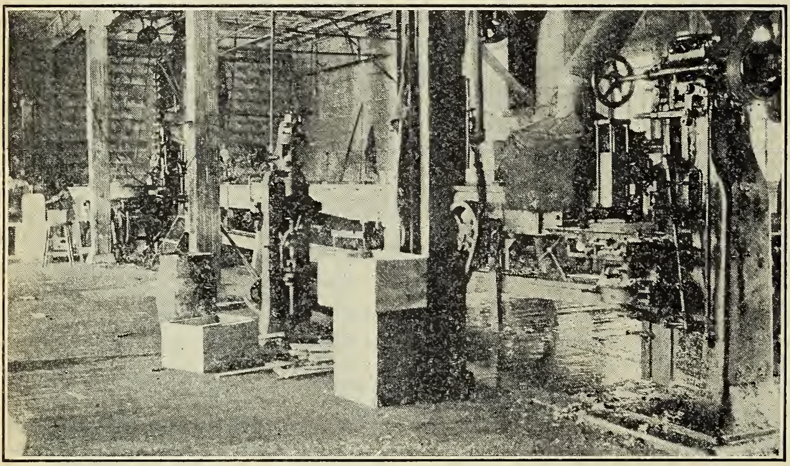


FIG. 10.—Canning equipment consisting of revolving table, exhaust box, and capping machine

brine and a uniform temperature should be maintained. Any variations will be reflected in the canned product.

FILLING THE CANS

After passing through the warming tank the sauerkraut is forked upon the canning table. In most factories the ordinary revolving table is used. As they pass before the five or six helpers seated around the table the cans are filled with sauerkraut. Since the filling is usually done by hand, those filling the cans should wear rubber gloves both for their own comfort and to prevent contaminating the sauerkraut.

The quantity of sauerkraut which the various-sized cans will hold has been carefully worked out and is now controlled by official ruling of the United States Department of Agriculture (p. 26). These rulings, which are not overexacting, relate to minimum requirements only. To put in less than the quantity specified is not permitted, but

more often the fault lies in putting in too much. A fairly definite head space should be left in each can, chiefly because it allows a free circulation of brine, which is essential to an even heating of the contents of the can, but also because it protects against swells, which result from overfilling.

HEATING THE CANNED SAUERKRAUT

After they have been filled the cans are carried by a conveying belt under flowing streams of hot brine which contains about 3 per cent of salt. When possible, sauerkraut juice should be used for this purpose, as it does not reduce any of the essential constituents of the sauerkraut.

After being flushed the cans pass into the exhaust. This may consist of one or more round metal inclosures filled with steam, through which the unsealed cans move in a circle, or it may be simply a long box filled with steam, through which they pass.

The cans next pass through the capping machine, which places a lid on each and seals it hermetically. From the capping machine the cans go to the "cooker," where they revolve slowly through steam or hot water. In some factories the sauerkraut is processed by subjecting the sealed cans to steam pressure in large retorts; in others the cans are immersed in boiling water. The latter method is well suited for processing large cans.

A high temperature is not essential to the preservation of canned sauerkraut. In actual practice it is seldom heated to more than 185° F.; often a lower temperature is used. The high temperature which is necessary in canning other vegetables not only is unnecessary for sauerkraut but is objectionable because it may produce undesirable changes in the color and texture.

Although experience has determined the degree of heat which is most effective in canning sauerkraut, manufacturers do not yet agree on the best method for its application. A common method of heating is to give a brief exhaust of from three to five minutes and a long "cook" of from 10 to 20 minutes, the exhaust being regarded merely as a preliminary to the "cook." This is not a good method for sauerkraut, as in canning this product the exhaust is especially important. Whatever method may be followed, the exhaust should be sufficient to destroy the lactic bacteria and yeasts (p. 22) and to insure a vacuum of at least 8 inches in the can after it is sealed and cooled. A high degree of vacuum gives an additional assurance of preservation and freedom from swells. The heavier the exhaust the greater will be the vacuum and the smaller the quantity of oxygen in the can. The exact time and temperature required to accomplish these results can not be stated arbitrarily, for the reason that they depend on variable factors, such as the size of the can, the temperature of the sauerkraut when put into the can, and the efficiency of the exhausting apparatus. Additional heating after the cans have been sealed should not be carried to the point of darkening the sauerkraut and destroying its crispiness. A temperature of 85° C. (185° F.) in the center of the can need not be exceeded. This temperature is easily attained by subjecting No. 3 cans after sealing to a temperature of 100° C. (212° F.) for 10 minutes or No. 10 cans to the same temperature for 30 minutes.

Some manufacturers are now canning sauerkraut with the use of an exhaust only, believing that by this method a better product is produced. The plan seems to be justifiable, but further experience is needed before it can be given unqualified approval.

From the "cooker" the cans go to a cooler, in which they remain until they are cooled to room temperature. From there they pass to the packing room, where they are labeled and prepared for shipment.

From the time the empty cans leave the storage room until they arrive in the shipping department, filled and ready for labeling, they never stop moving. In some factories the time required for a can to pass through the various processes is not more than 20 minutes.

SWELLS

The swelling of cans, a matter of practical importance to every canner, has a special significance to the canner of sauerkraut because canned sauerkraut is especially liable to spoilage of this type. Swells are caused by the formation of gas within the can after it is sealed; they may occur in any can which has not been sufficiently heated.

Swells in sauerkraut are of two distinct types, differentiated both by the origin and the nature of the gas formed. In swells of one type the gas is formed by the action of microorganisms; it consists almost entirely of carbon dioxide. Swells from this cause generally occur soon after canning unless the cans are held at a very low temperature. They may occur, however, whenever temperature conditions are favorable. The prevention of this kind of swells depends entirely upon the application of sufficient heat in canning to destroy the organisms which produce the gas. The thermal death point of the lactic group of bacteria in sauerkraut juice is approximately 55° C. (131° F.) for five minutes, and that of yeasts is about the same. Experiments (*13*) have shown, however, that a temperature of 70° C. (158° F.) in the center of the can is necessary to prevent the swelling of cans by microbial action when they are stored at room temperature; a lower temperature is not sufficient for this purpose. A temperature of 70° C. (158° F.), therefore, seems to be the minimum to which sauerkraut should be subjected.

Swells of the second type result from chemical action. Acids are valuable adjuncts in the preservation of sauerkraut, but they may be harmful to the containers. Acid brine has a corrosive action on the metals of the can, which may result in the formation of enough hydrogen gas to cause its distention. This action takes place slowly and, as a rule, swells of this type are found in sauerkraut only after the cans have been stored several months. Swells may occur sooner, however, in cans which are not properly exhausted or which are overfilled either with sauerkraut or brine. McConkie (*14*) emphasized the relation of these factors to the formation of hydrogen swells. He also called attention to the importance of promptly cooling cans to room temperature after processing.

In spite of the best possible canning technic, every can of sauerkraut contains potential agencies for degenerative changes. Safety and efficiency, therefore, demand the rapid turnover of the product; a can of sauerkraut should never be placed on a shelf and forgotten. Some system of coding or dating that will warn against too long storage of this product is imperative.

SANITATION IN SAUERKRAUT PRODUCTION

AT THE FACTORY

If made by proper methods and under sanitary conditions, sauerkraut is exceptionally free from extraneous material. As a rule, the raw materials from which it is made are pure and wholesome and are subjected to little handling in the process of manufacture. Improper methods of manufacture and unsanitary conditions, however, will be reflected in the product. A desirable product can not be expected from a bad environment. It is important that a sauerkraut factory should be well lighted and ventilated. The entire establishment, especially those parts of it which come in contact with the cabbage, should be kept as free as possible from dust and dirt. The personal cleanliness of all employees should be insisted upon. These precautions not only are necessary for sanitation but are important in that they prevent the entrance of those contaminating organisms which are injurious to the process of fermentation.

SANITARY MEASURES FOR HANDLING BULK SAUERKRAUT

ON THE PART OF THE PACKER

The sanitary precautions which have been advised for the production of sauerkraut should not cease with its removal from the tank. This is especially important when it is to be marketed in bulk.

On removal from the tank sauerkraut should be handled expeditiously and carefully to avoid contamination. Yeasts are the chief cause of spoilage in bulk sauerkraut. These microorganisms, which are usually present, though inactive, in the tank, quickly become active when the sauerkraut is exposed to the air. This is especially true of those destructive types of yeast which under favorable conditions grow rapidly and may soon produce changes in the color and other essential qualities of this product which render it unsalable. Widespread spoilage of bulk sauerkraut from the activity of yeasts has been reported by Peterson and Fred (*16*). The important factors in preventing their growth are low temperature and the exclusion of air. Bulk shipments of sauerkraut are preserved more successfully if in packing enough juice is included to fill the container. This juice excludes air and does not reduce the acidity or other normal constituents of the sauerkraut. It likewise conserves much nutrient material which otherwise is wasted.

Sauerkraut should be packed in clean, tight containers, which should be filled full, closed tight, and shipped promptly.

ON THE PART OF THE DEALER

In order that a wholesome product may reach the consumer, it is essential that local dealers in sauerkraut should cooperate with manufacturers in measures that will preserve its quality. Among these measures cold storage is important and should always be used, if possible. It is, in fact, difficult to see how bulk sauerkraut can be kept in a warm room and still remain fit for consumption. Regardless of the temperature at which they are stored, however, barrels containing sauerkraut should always be kept well covered,

preferably with a damp cloth, and weak brine (4 ounces of salt to a gallon of water) should be added to the sauerkraut when required, to prevent exposure to the air. The addition of brine means, of course, the reduction of acidity, but reduction of acidity by the addition of brine is preferable to its destruction by the action of yeasts.

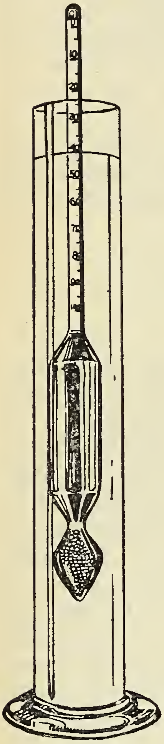
Almost all dealers who sell bulk sauerkraut not of their own manufacture purchase it in barrels of standard size. This is done probably for economic reasons, and for those who handle a large volume of business it is, perhaps, justifiable. For small dealers, however, the purchase of sauerkraut in small barrels or kegs would seem to be more sanitary, as it would mean a more rapid turnover of the product.

Displaying sauerkraut uncovered on the counters of stores and markets, where it is exposed to contamination from dust and, perhaps, handling, is reprehensible. If sauerkraut must be placed on exhibition it should be protected by a glass covering.

TESTS

SALT TEST

The salt strength of brine is determined by means of a salinometer (fig. 11), which should form a part of the equipment of every sauerkraut factory. The salinometer scale is graduated into 100°, which show the range of salt concentration between 0°, the reading for pure water at 60° F., and 100°, which indicates a saturated salt solution (26½ per cent). In a pure salt solution the salinometer shows accurately the percentage of salt. As sauerkraut brine, however, is not a pure salt solution but contains much other soluble material, a salinometer reading can be regarded only as a measure of its total solids. This may vary greatly in different samples, depending not only on the quantity of salt added but upon the moisture content and the soluble constituents of the cabbage. Under ordinary conditions when 2.5 per cent of salt has been added a salinometer reading of about 17° is obtained.



No 11.—Salinometer

ACIDITY TEST

For determining the acidity of the brine in a tank of sauerkraut a small sample should be taken by suction through a glass tube. This sample should be obtained at least 2 feet below the surface and from the sides of the tank. Brine obtained by opening the bottom vent should not be used, as it may differ from that above and is not a representative sample. Brine from the middle of the tank would best represent the average acidity in the tank. If possible, a hole should be provided in the tank for obtaining this brine.

The acidity of sauerkraut may be determined with sufficient accuracy by titration of the brine against an alkaline solution of known

strength. A normal solution of sodium hydroxide is generally used. The test gives no information regarding the kind of acid in the brine but determines only the quantity of normal alkali which is required to counteract its acidity and produce neutrality. The quantity of normal alkali used to produce neutrality multiplied by the appropriate figure for the acid gives the number of grams of acid per 100 cubic centimeters of brine. This factor for lactic acid is 0.09. Although the acid in sauerkraut is not entirely lactic, it is mainly lactic, and it is therefore calculated as lactic acid.

Grams of acid per 100 cubic centimeters of brine is not quite the same as percentage by weight, but it is nearly the same and is often referred to as percentage.

The methods of making titrations differ slightly in detail, but any of them may be easily followed. Although not the simplest, the following method is perhaps the best. Figure 12 shows the apparatus used for the acidity test.

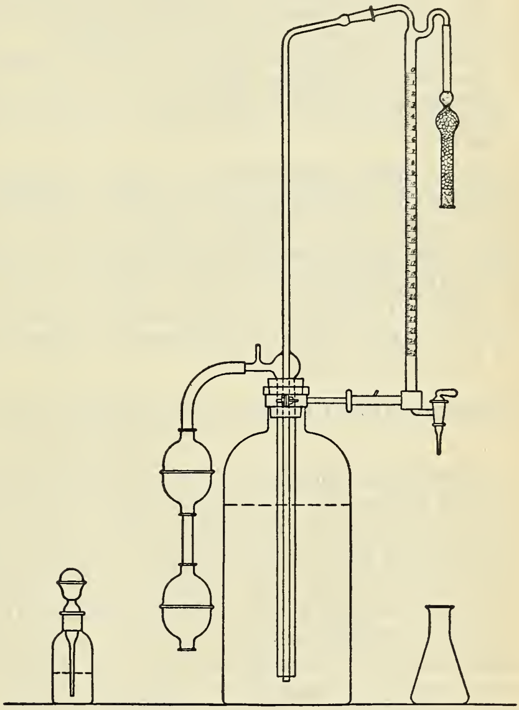


FIG. 12.—Titration apparatus

With a pipette transfer exactly 5 cubic centimeters of the sample of brine to a 100-cubic centimeter Erlenmeyer flask. Add to this 45 cubic centimeters of distilled water and 3 or 4 drops of a phenolphthalein solution. Then run in slowly from a burette a one-twentieth normal solution of sodium hydroxide. While this is running in shake the flask constantly and watch it carefully. As soon as a permanent faint pink tint is produced throughout the solution the neutral point has been reached and no more should be added. It is important that the addition of alkali stop at the first appearance of the pinkish tint. Read to a fraction on the burette the number of cubic centimeters required to neutralize the brine. Multiplying this number by 0.09 gives the grams of acid, calculated as lactic, in 100 cubic centimeters.

If it is desired to use a one-tenth normal sodium hydroxide solution start with 10 cubic centimeters of brine and 40 cubic centimeters of distilled water and proceed as before.

The acidity may be tested more simply and the result may be read directly in percentage of lactic acid by the following method: Use

a one-ninth normal solution of sodium hydroxide (1 part normal sodium hydroxide solution to 8 parts distilled water), place 10 cubic centimeters of brine in the flask, add 40 cubic centimeters of distilled water, and proceed as before. The number obtained divided by 10 gives the percentage of lactic acid in the brine.

For making the acidity test the following apparatus and chemicals should be on hand:

One 25-cubic centimeter automatic burette graduated in one-tenths cubic centimeter.

Three 10-cubic centimeter pipettes.

Three 5-cubic centimeter pipettes.

Three 100-cubic centimeter Erlenmeyer flasks.

Two 50-cubic centimeter cylindrical graduates.

Two long glass tubes for collecting samples from the tank. These should be of heavy glass and not less than 3 feet long.

Two liters of normal sodium hydroxide solution of the strength desired.

Two liters of distilled water.

Five hundred cubic centimeters of a phenolphthalein solution prepared by dissolving 0.5 gram of phenolphthalein in 100 cubic centimeters of 50 per cent alcohol.

It is more convenient to keep a supply of the phenolphthalein solution in a small dropping bottle and from this add at each test 3 or 4 drops. As ordinary well or hydrant water may contain alkaline salts, only distilled water should be used. This can be obtained from any drug store.

All the foregoing apparatus and chemicals may be obtained ready for use from dealers in laboratory apparatus and supplies at a cost of from $10 to $15.

FEDERAL REGULATIONS GOVERNING THE MANUFACTURE AND SALE OF SAUERKRAUT

Sauerkraut which is to be shipped from one State to another or offered for sale in the possessions or Territories of the United States or the District of Columbia must conform to the requirements of the Federal food and drugs act. Under this act the following regulations governing the quality and canned weights of sauerkraut have been adopted by the United States Department of Agriculture. As these regulations are subject to change, anyone engaged in the manufacture of sauerkraut on a commercial scale should obtain the most recent information regarding them. This information may be obtained from the Food, Drug, and Insecticide Administration, United States Department of Agriculture, Washington, D. C.

WEIGHTS OF SAUERKRAUT IN CANS OF VARIOUS SIZES (*21*)

Investigations have shown that properly filled cans should yield at least the following drained weights of sauerkraut, the weight being determined in each instance by draining for two minutes on a ⅛-inch mesh screen:

No. 2: $3\frac{7}{16}$ by $4\frac{9}{16}$ inch sanitary, and 3⅜ by $4\frac{9}{16}$ inch hole and cap	(16 ounces) 1 pound.
No. 2½: $4\frac{1}{16}$ by $4\frac{11}{16}$ inch sanitary, and 4 by 4¾ inch hole and cap	(23 ounces) 1 pound 7 ounces.
No. 3: 4¼ by 4⅞ inch sanitary, and $4\frac{3}{16}$ by 4⅞ inch hole and cap	(27 ounces) 1 pound 11 ounces.
No. 10: $6\frac{3}{16}$ by 7 inch sanitary, and 6¼ by 6¾ inch hole and cap	(80 ounces) 5 pounds.

A can of a size not mentioned here should yield a drained weight which bears the same relation to the drained weight indicated for the can nearest in size as that existing between the capacities of the cans in question.

All cans should be packed with the maximum amount of sauerkraut which is consistent with maintenance of quality, and the cut-out weights mentioned in the preceding list should be exceeded whenever this is possible without impairment of quality.

In making declarations under the net weight requirements of the Federal food and drugs act the total weight of the contents of the can, liquid included, should be declared.

DEFINITION AND STANDARD FOR SAUERKRAUT (*20*)

The following revised and amended definition and standard for sauerkraut adopted by the joint committee on definitions and standards was made effective by order of the Secretary of Agriculture, August 18, 1925:

Sauerkraut is the clean, sound product, of characteristic acid flavor, obtained by the full fermentation, chiefly lactic, of properly prepared and shredded cabbage in the presence of not less than two per cent (2%) nor more than three per cent (3%) of salt.

It contains, upon completion of the fermentation, not less than one and one-half per cent (1.5%) of acid, expressed as lactic acid. Sauerkraut which has been rebrined in the process of canning or repacking contains not less than one per cent (1%) of acid, expressed as lactic acid.

FLOW SHEET FOR COMMERCIAL PRODUCTION OF SAUERKRAUT

Use matured cabbage of suitable variety. Wilt in bins from 24 to 48 hours before cutting.

Cut cores into small pieces. Cut rest of head into shreds, approximately $\frac{1}{32}$ inch thick.

Salt shredded cabbage in proportion of not less than 2 or more than 3 percent by weight. Distribute salt evenly.

Ferment. Continue fermentation until acidity no longer increases. Maximum acidity should not be less than 1.5 per cent, expressed as lactic.

A temperature of 30° C. (86° F.) in the shredded cabbage is most favorable for the start of fermentation. If temperature is decidedly below this, preheating will insure better results.

Empty tanks soon after fermentation is completed.

Distribute in bulk or in cans

Pack bulk sauerkraut in clean tight containers. Add sauerkraut juice to prevent exposure to air. After repacking, the sauerkraut must contain at least 1 per cent of acid, expressed as lactic.

Local dealers should keep sauerkraut covered, and in cold storage, if possible. Add weak brine as required, to keep sauerkraut from the air.

Warm sauerkraut in sauerkraut juice.

Fill cans. Leave head space in cans.

Flush cans. After cans have been flushed, brine must contain at least 1 per cent acid, expressed as lactic.

Exhaust cans. This should bring contents in the center of can to at least 70° C. (158° F.).

If additional heating is given after cans are sealed, it need not exceed 10 minutes for No. 3 cans or 30 minutes for No. 10 cans at 100° C. (212° F.).

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